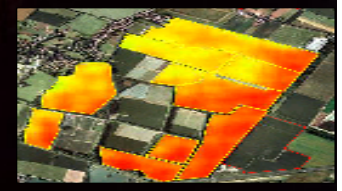
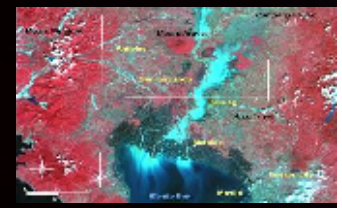
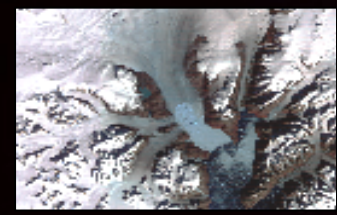
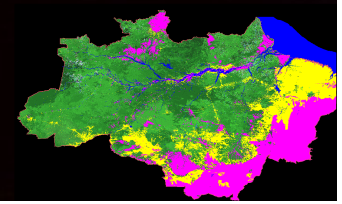
The Next Generation DMC satellites;
UK-DMC-2 and Deimos-1









Paul Stephens
Director of Sales & Marketing
DMC International Imaging Ltd

JACIE, Washington DC 2009

The Disaster Monitoring Constellation

SURREY SATELLITE TECHNOLOGY LTD

The Consortium

dmc International Imaging

The Coordinator

The Constellation

Applications;
Commercial, Government and Humanitarian

DMCii and SSTL Company Organisation

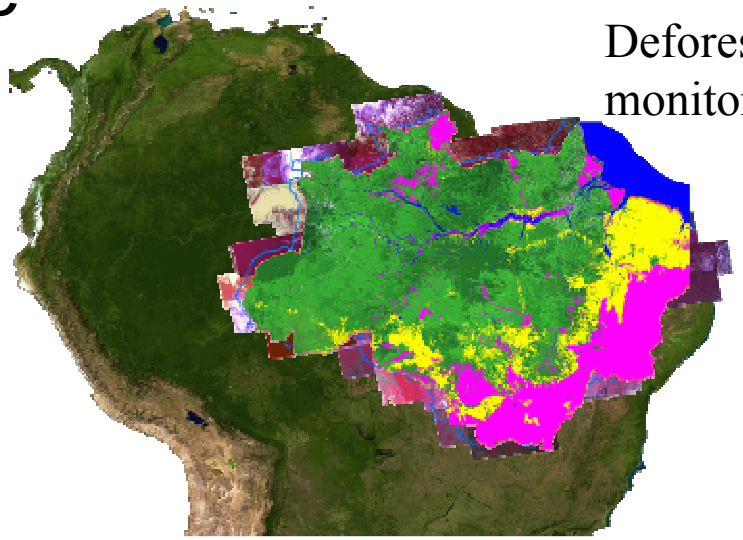
- Based in UK
  - Operational units
    - DMCii, Data sales and value-added data products and direct downlink services
    - SSTL-UK, Satellites and supporting infrastructure
    - SST-US, created in 2008 to develop US market
- DMCii
  - Established 2004, now 15 staff
  - International coordinator of disaster response and constellation activities
  - Commercial data services supplied world-wide
- SSTL
  - Established in 1985, now 300+ staff
  - Over 37 satellites launched
  - Currently in production 9 satellites

Applications of DMC imagery

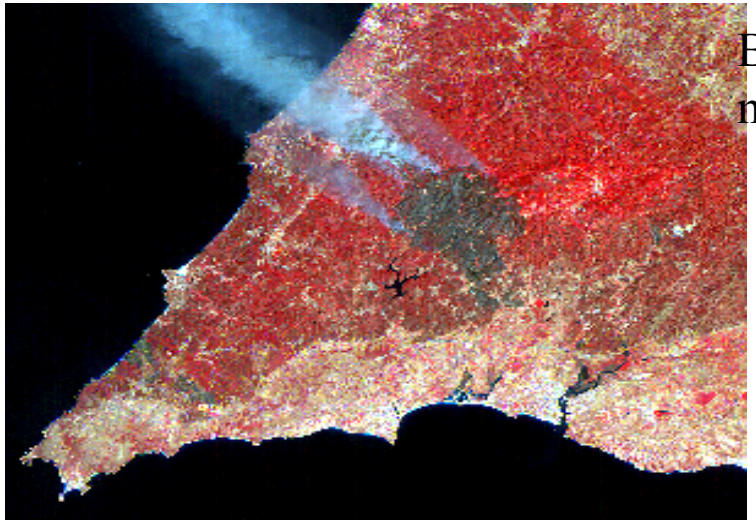
Benefits of rapid revisit and wide area coverage

Precision Agriculture

Deforestation monitoring



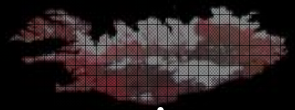
Flood mapping



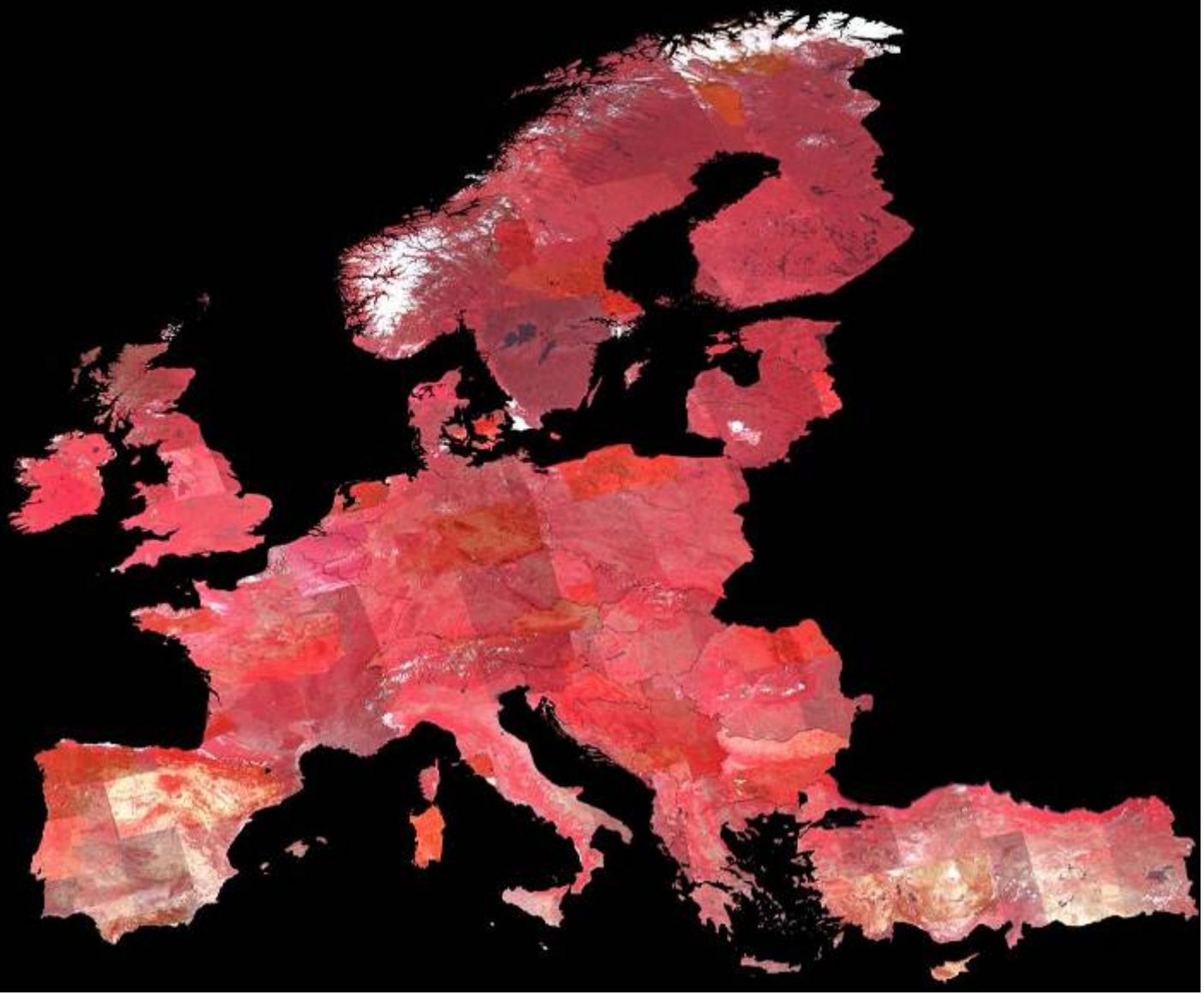
Burnt Area mapping

Monitoring Europe;
Complete coverage in one year

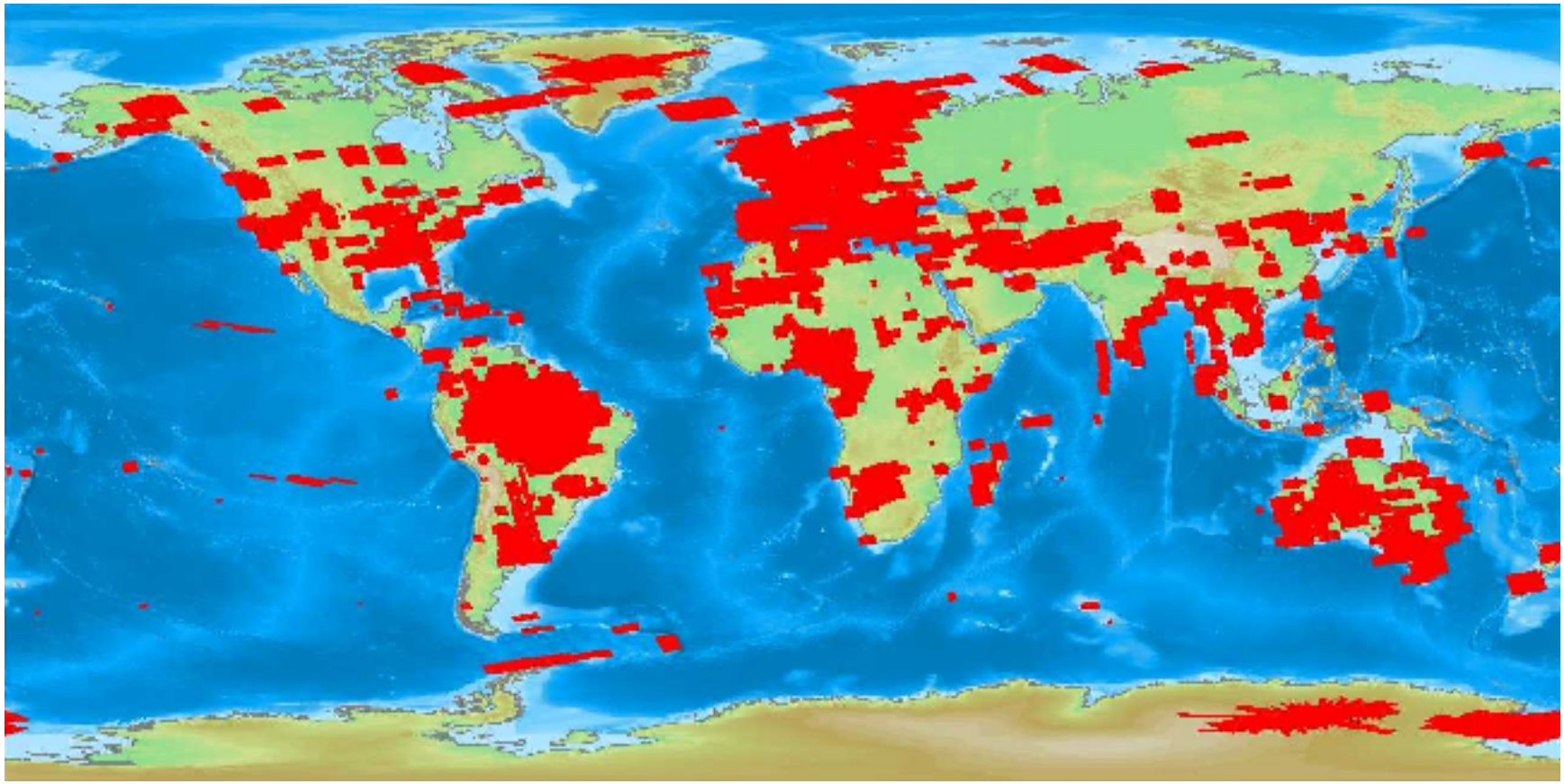
Delivered



- 38 countries
- 5.8 million km^2
- Individual acquisition windows
- Individual projections
- <5% cloud
- 32 metre gsd

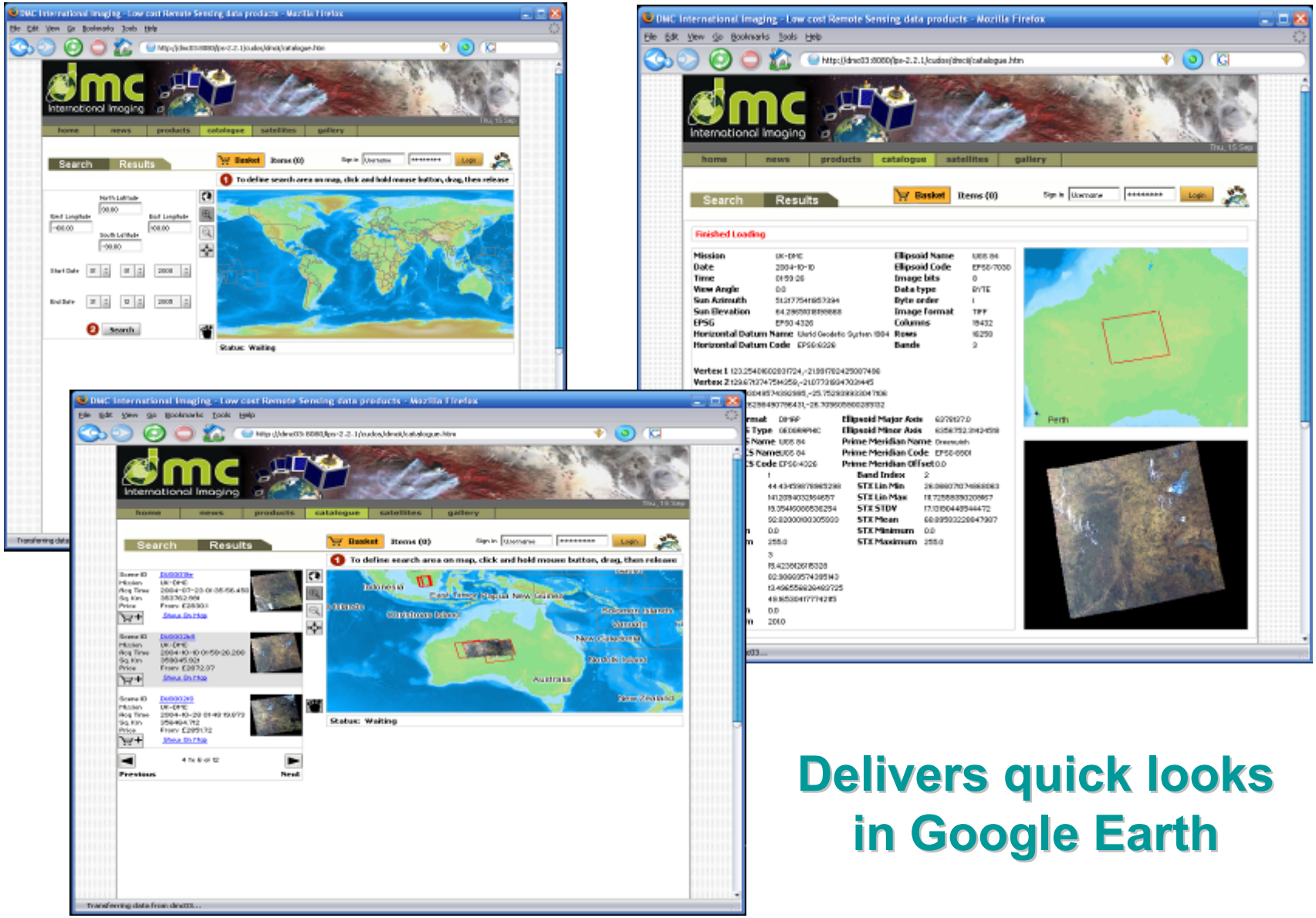


DMCii 32m Archive Data



Three new 20 metre class satellites can deliver multi-season World coverage

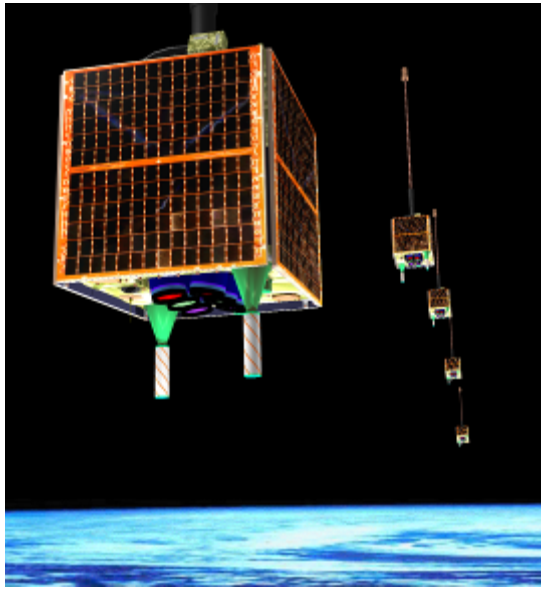
On-Line Archive Search Tools

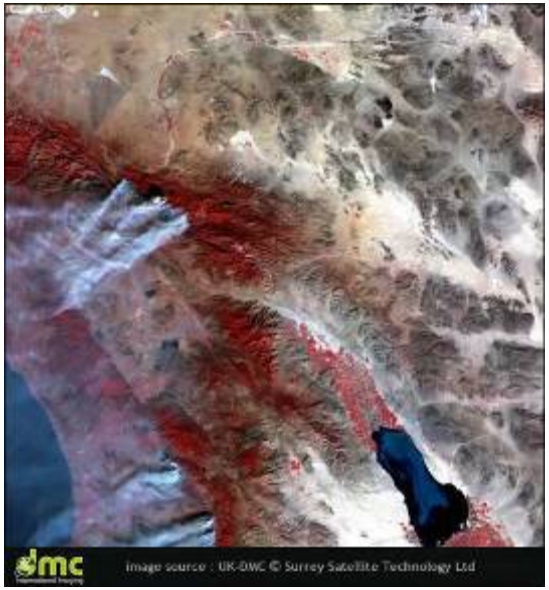


Delivers quick looks in Google Earth

DMC – first generation

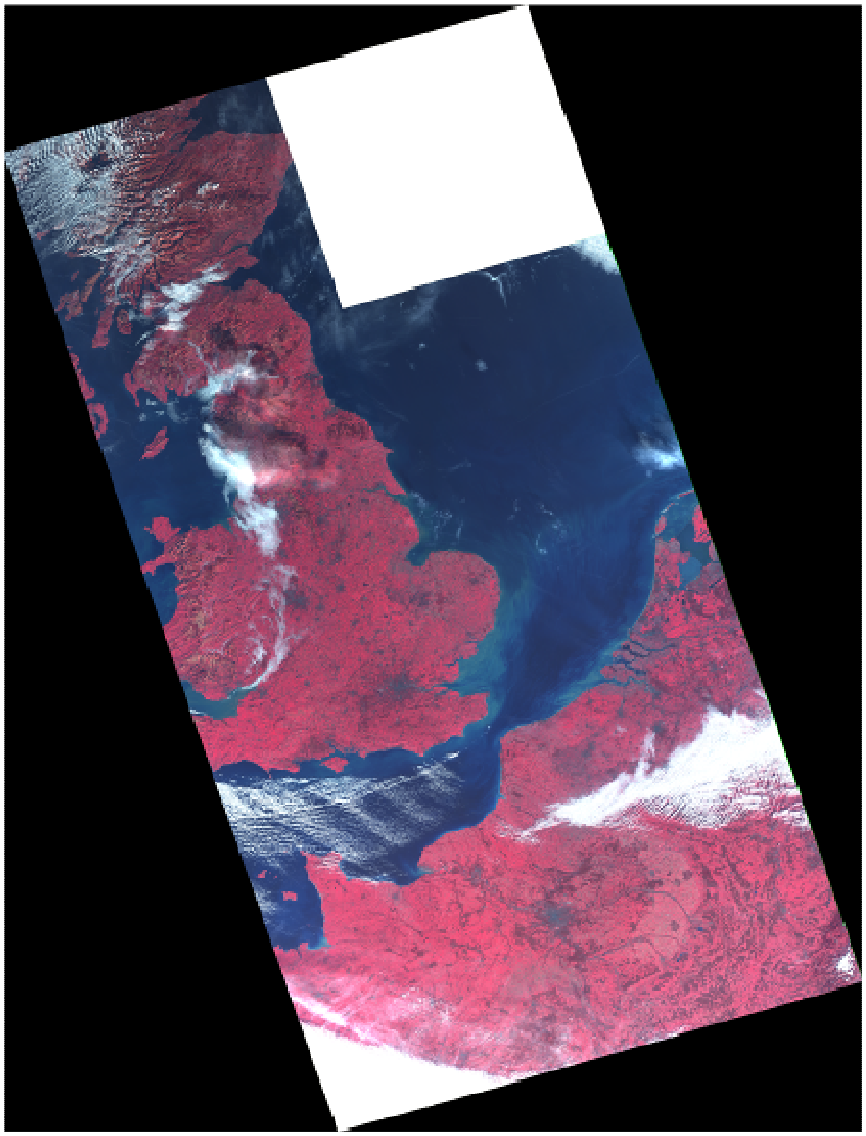
- Constellation of 5 spacecraft launched 2002 - 2004
  - 32-m Ground Sampling Distance
  - Red Green and Near-infrared (Spectral ranges as Landsat 2,3,4)
  - Wide 650+km swath
  - Daily Global Revisit as constellation
  - Unique International Cooperation
  - Supporting the International Charter for Space and Major Disasters
- DMCii coordinates world-wide commercial service





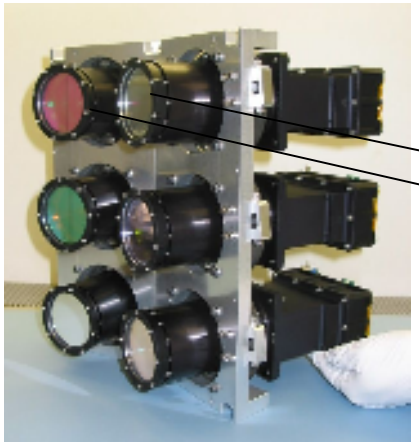
Constellations against Cloud - UK weather

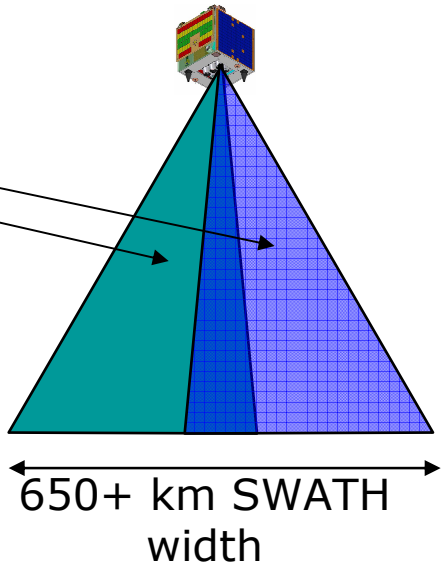
Multiple MODIS images May 2006



Single DMC image April 2007

Current Constellation





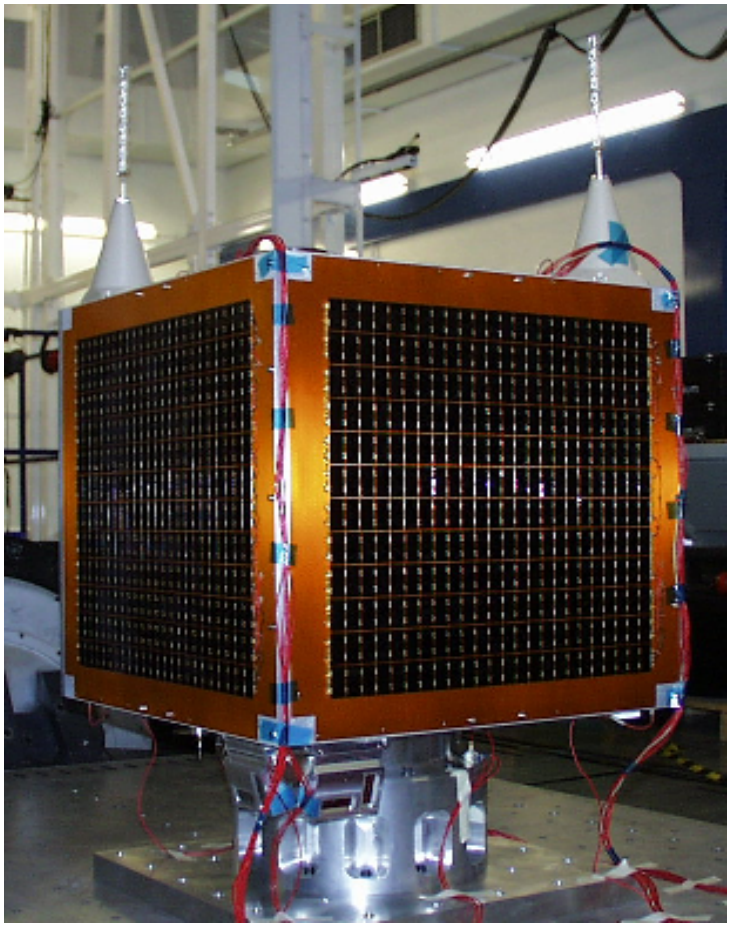
Multispectral

- 32 metre
- Revisit – daily
- Accurate, Orthorectified imagery
- Fully Radiometrically Calibrated

Filters: Landsat equivalent

- NIR 0.77 - 0.90µm ETM+4
- Red 0.63 - 0.69µm ETM+3
- Green 0.52 - 0.60µm ETM+2

Disaster Monitoring Constellation (DMC)



- Sub 100 kg satellite
- 5 year life

- Three spectral bands (equivalent to bands 2, 3 and 4 of Landsat)

- 1st generation imager (32m GSD)
  - Currently four in orbit (three in one plane and fourth is second plane)

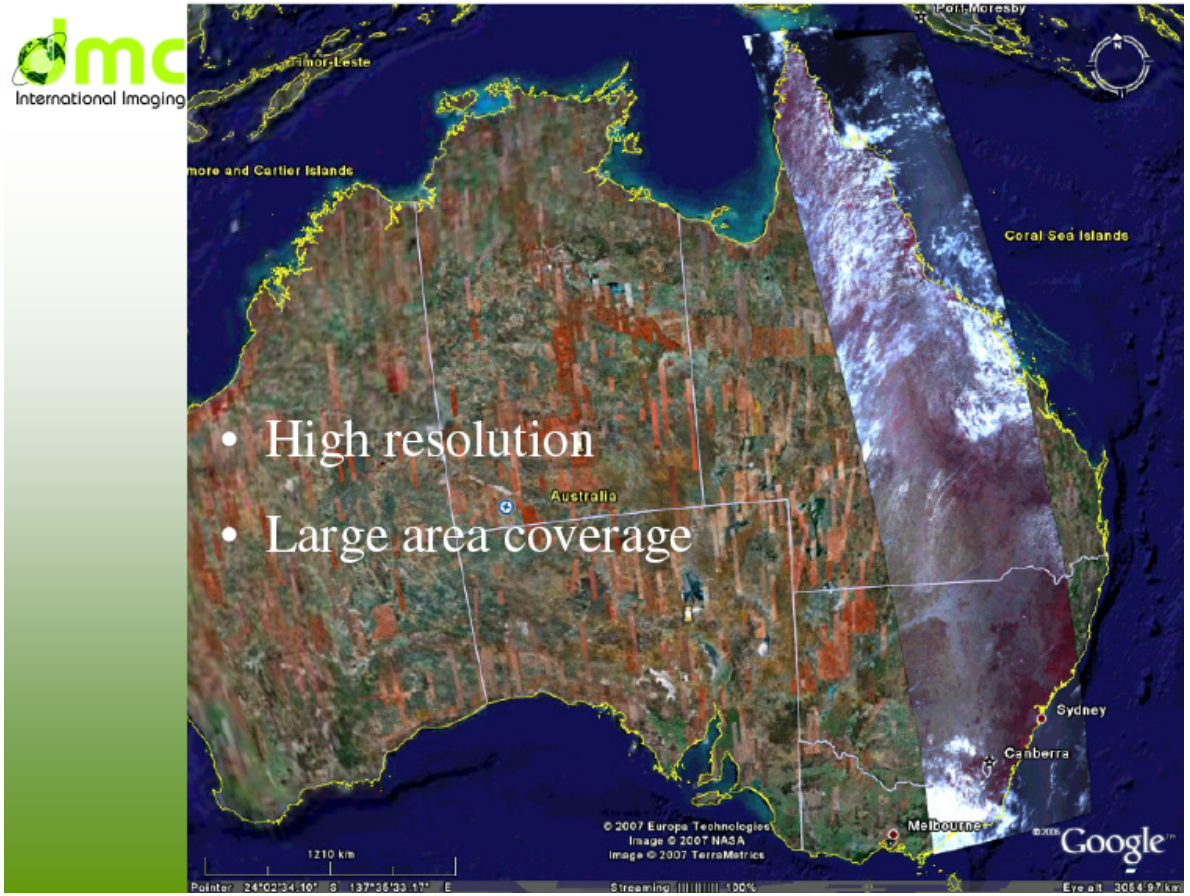
- 2nd generation imager (22m GSD)
  - Three more DMC satellites

- Older satellites gravity gradient boom stabilised

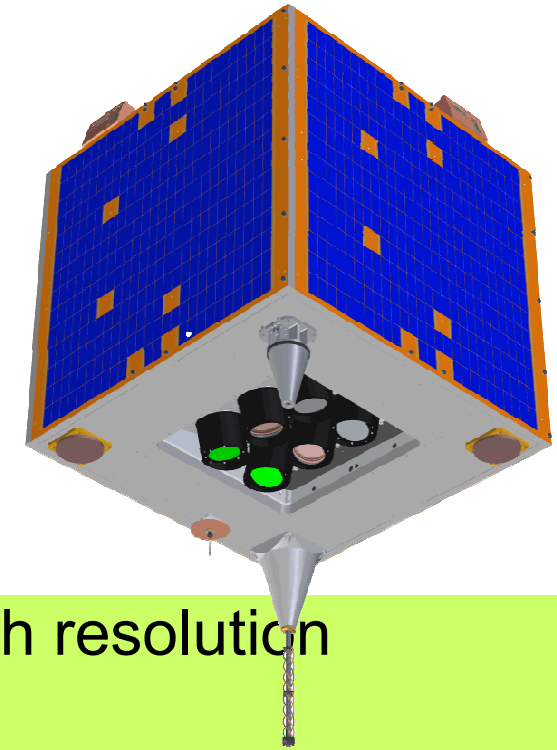
- Next generation 3-axis stabilised

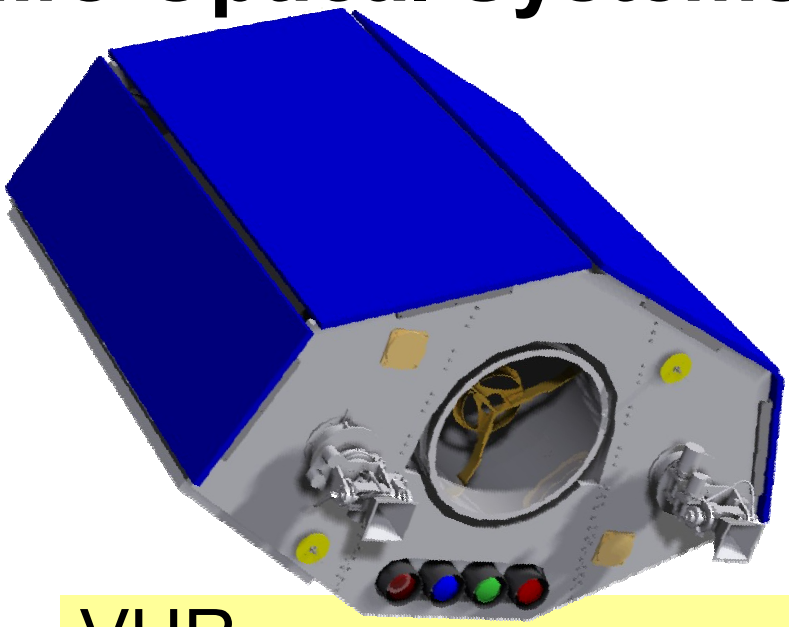
DMC Imager

- Swath 640 km across and can be thousands of kilometres long



Next Generation DMC Optical Systems





High resolution

- UK DMC2 & Deimos-1 satellites
- Nx satellite

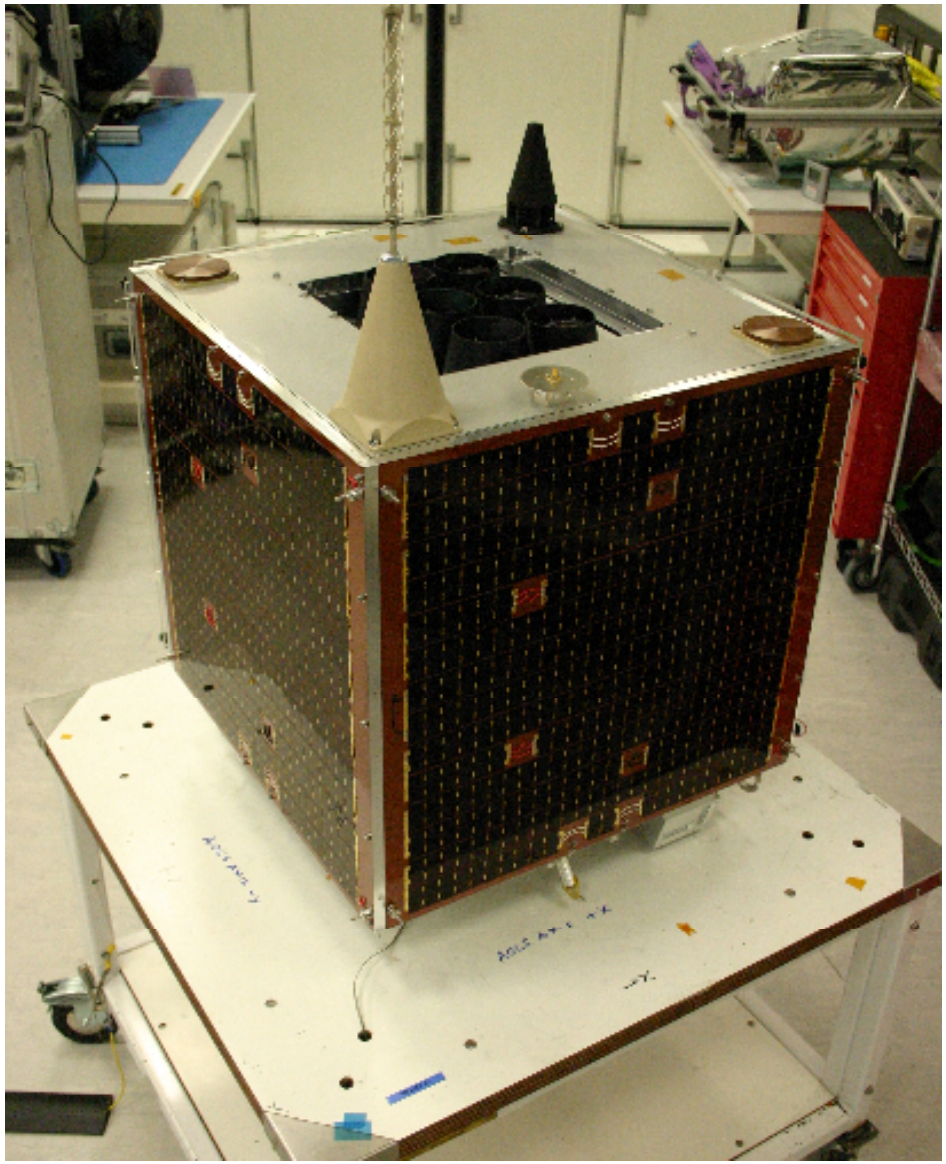
- High Resolution Imager
  - 22m 3-band multispectral
  - 650km swath
  - X-band downlink
  - Enhanced along track imaging
  - Near Real Time Direct Downlink

VHR

- Nigeriasat-2

- VHR Imagers
  - 2.5m PAN
  - 5.0m 4-band multispectral
- HR Imager
  - 32m 4-band multispectral
- Advanced modes
- Dual X-band downlink

UK-DMC-2 & Deimos-1

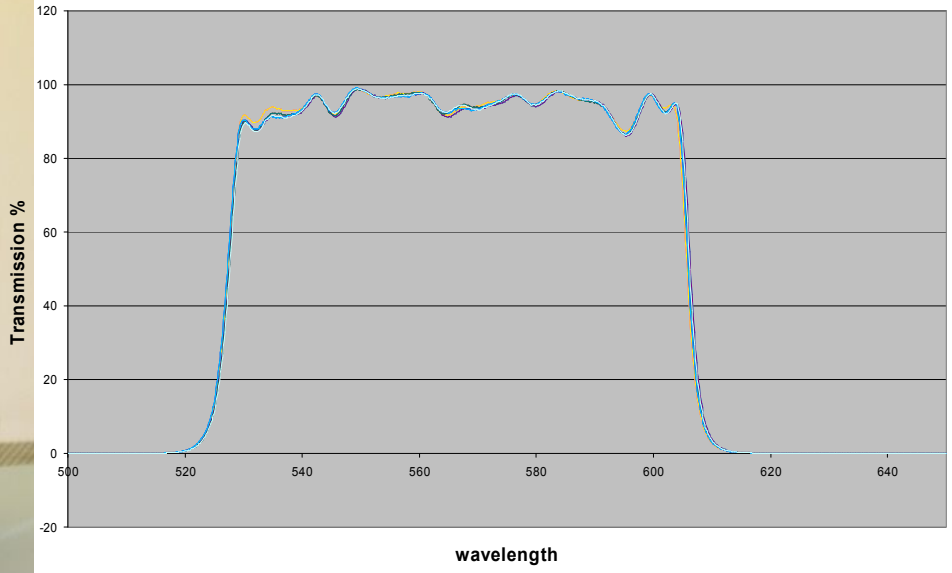


DMC Imager Bands – Spectral Response Function

Detector 5μm – 15,000 pixels

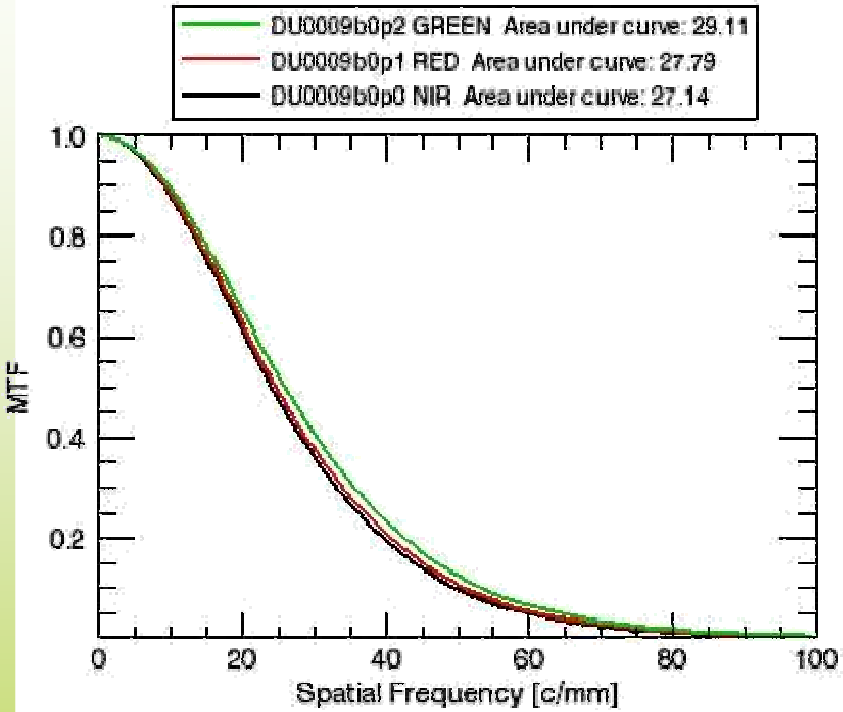
(improved from 1st generation 7 μm 10,000 pixels)

ETM+ Band	Band Edges 50% Relative Transmittance Lower (nm)	Upper (nm)	Avg. In-band Transmittance
2	523 ± 6	605 ± 6	0.85
3	629 ± 6	690 ± 6	0.85
4	774 ± 6	900 ± 7	0.85



1st and 2nd generation Imager Characteristics -
Modulation Transfer Function (MTF) and Signal to Noise ratio (SNR)

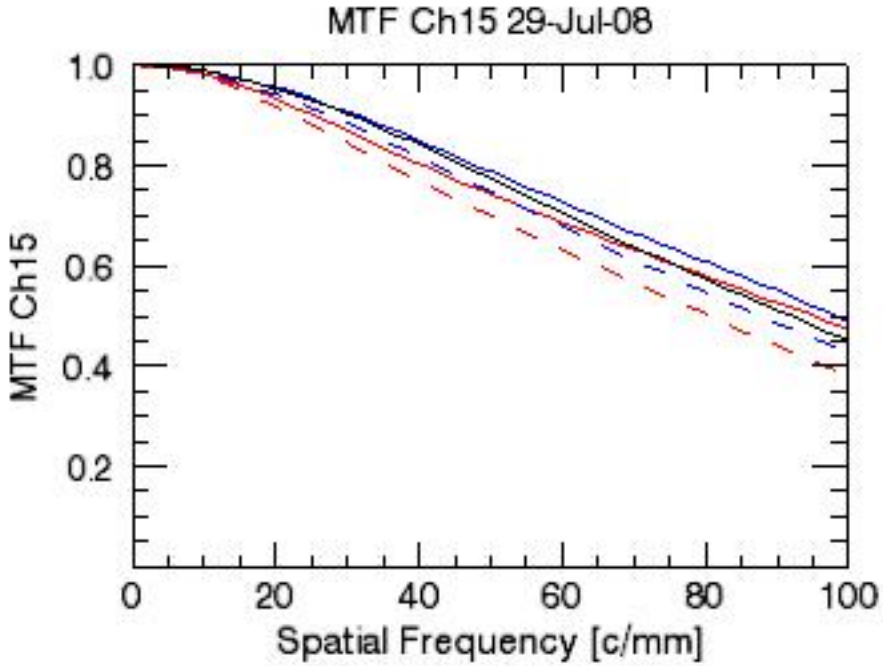
1st Generation (Green band)



SNR of 110-1 in green, 90-1 in red and 70-1 in the NIR. (Antarctic)

Note measurements made with non-optimal electronic gains

2nd Generation (Green band)

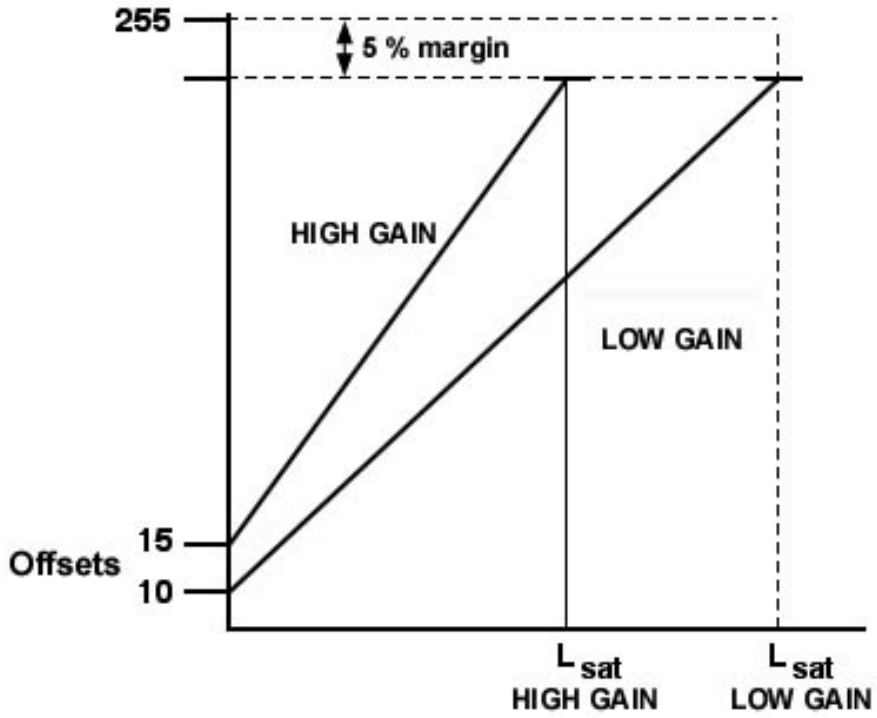


SNR improved to 120:1

Integration time and Electronic gain

- 1st generation Imagers had fixed gain and variable integration time which gave some flexibility in targeting

- 2nd generation imagers have optimal settings for gain and integration time (gain will not need to be changed in normal operation, but can be). Like Landsat.



2nd generation DMC Imagers

- Improved ground sampling distance to 22m (doubles pixel density)
- Improved MTF (effective spatial resolution)
- Improved SNR (detectors, electronics and operational changes)
- Reduced striping (changed electronics and operational changes)
- Improved stability (changed wheels and absence of boom)
- Improved geometry (stability and engineering improvements)

Calibration of the DMC constellation

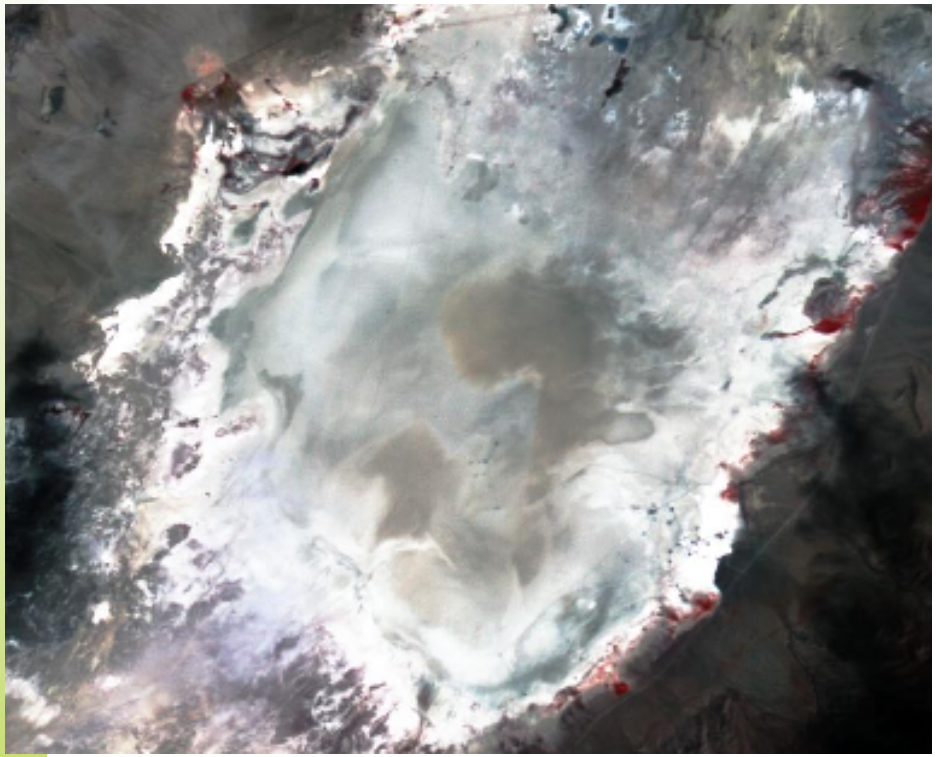


Image acquired July 2008 by Nigeriasat-1 over Railroad Valley Nevada

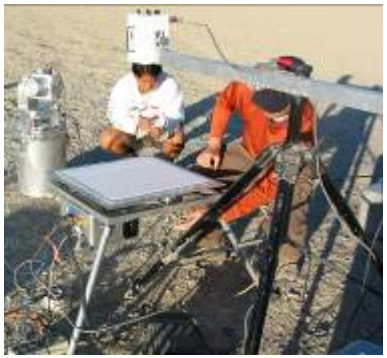
- Small satellite constellation, no on-board calibration
- Pre-launch calibration defines initial coefficients
- In orbit each sensor tends to change characteristics so a post-launch calibration is required
- Vicarious calibration using Gold standard satellite over target sites such as Railroad Valley in Nevada.
- Cross calibration of constellation over Antarctica

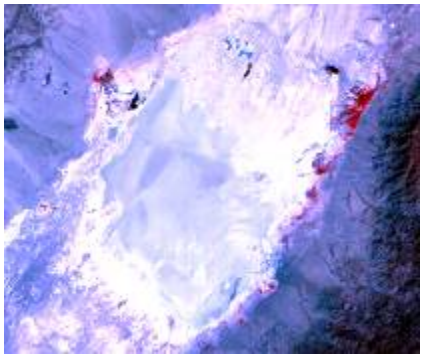
DMC Radiometric Calibration

Principal Scientist Dr Stephen Mackin (Surrey Space Centre, UK)

- Annual Absolute Calibration since July 2004
  - Railroad Valley, Nevada instrumented test site
  - Facilities & TOA radiance supplied by Arizona Uni., USA
- Ongoing Monthly Relative Calibration
  - 'Pacific at Night' & 'Antarctic & Greenland' images
- No significant performance change noted
- Excellent radiometry <5% error
- Cross calibration error <0.5%
- Full documentation available

DMCii leads the CEOS WG on cross calibration



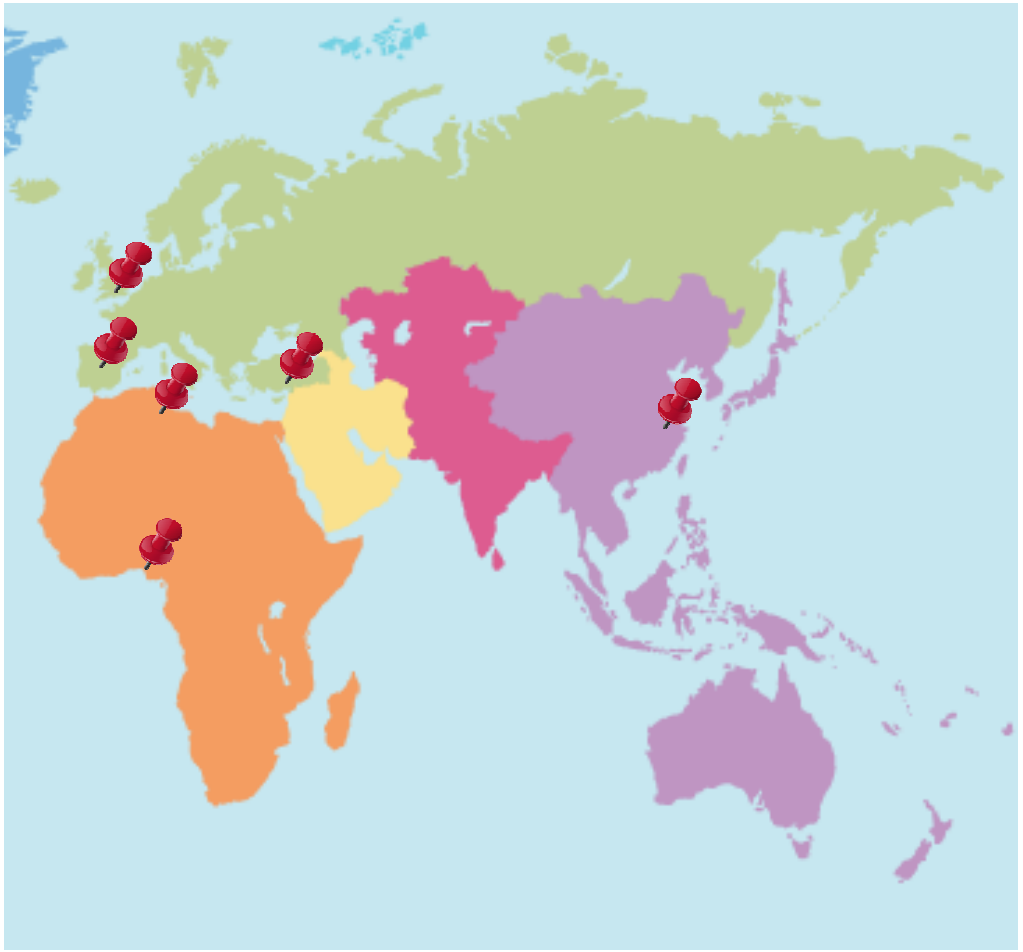


QA/QC

- Current QA/QC
  - Largely manual checks
    - Saturation
    - Striping artefacts
    - Overall quality (SNR, contrast)
    - Geometrical checks on r.m.s. errors
    - Applied to most images
- 2nd Generation QA/QC
  - Automated procedure
  - Based on modular QA/QC system proposed to ESA
  - “Controls” data quality and flags any anomaly
  - Applied to every image

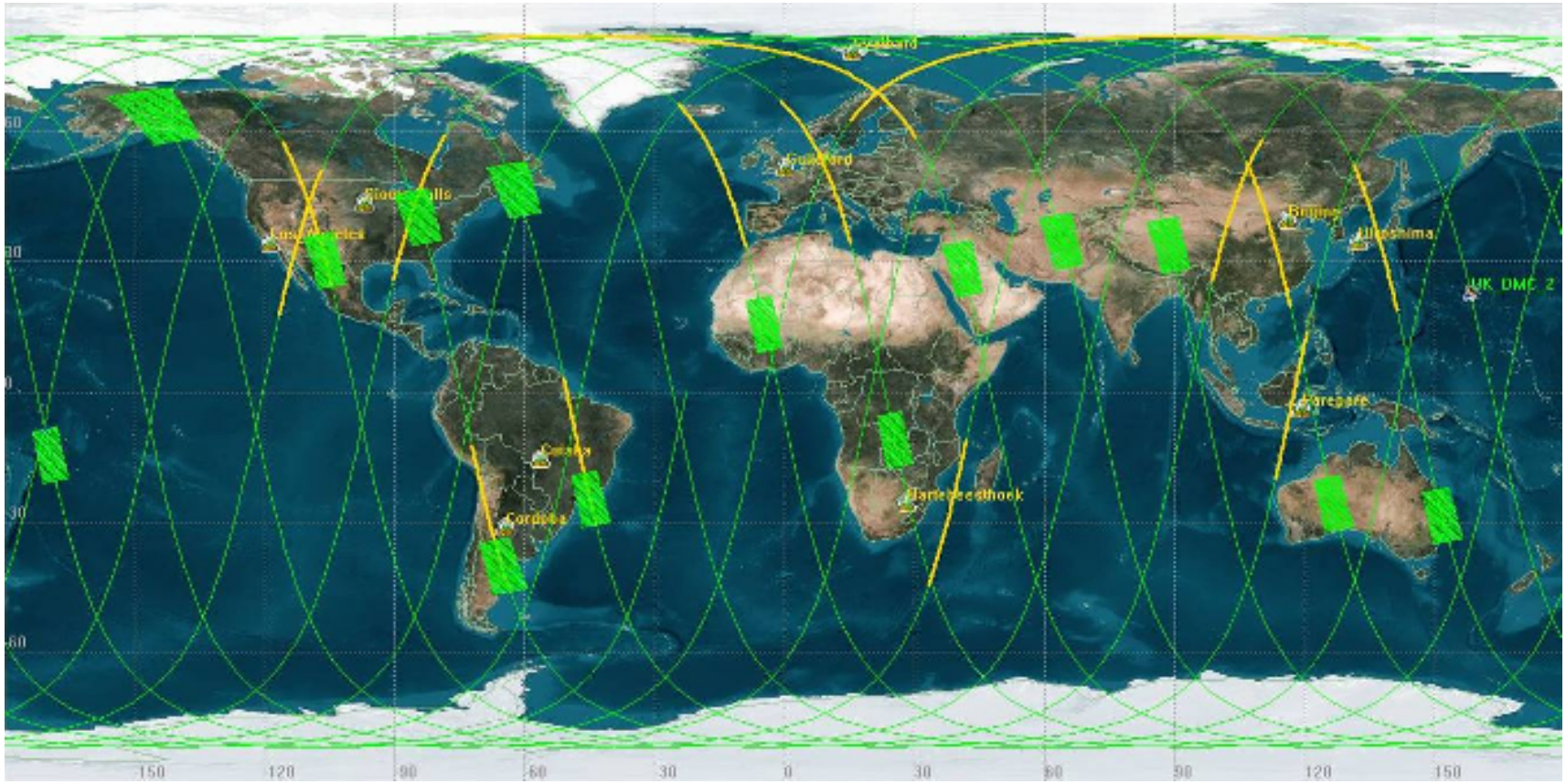
DMC groundstation network

- Satellite owner stations
  - DMCii/SSTL, UK
  - CNTS, Algeria
  - TUBITAK, Turkey
  - BLMIT, China
  - NASRDA, Nigeria
  - Deimos,Spain



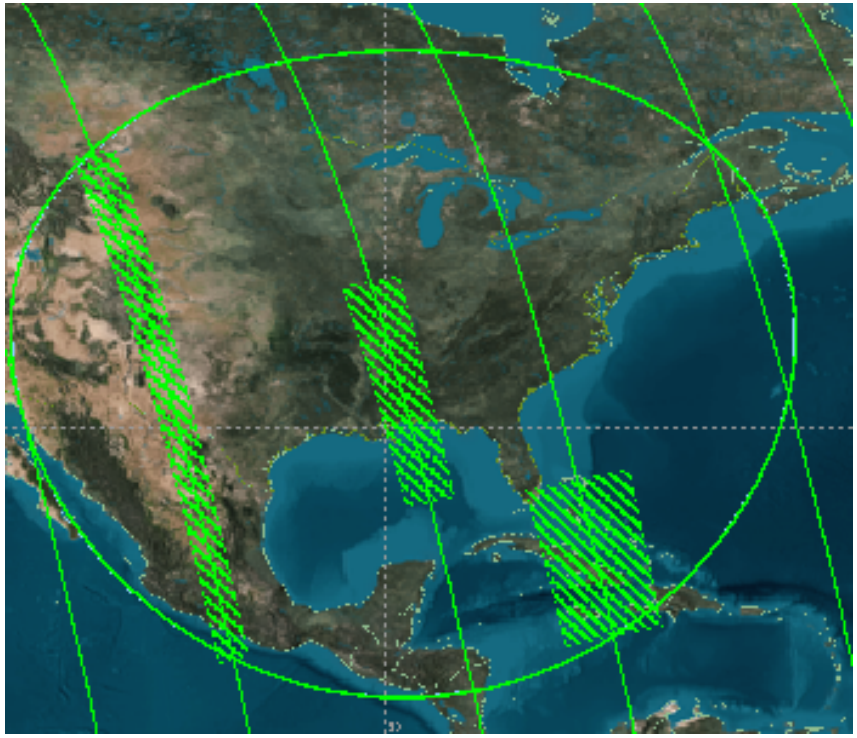
Distributed Network Throughput Performance for 1 satellite

- Up to 11 million km^2 of imagery per day
- 2 weeks to cover the equivalent of the Earth's landmass
- Example daily coverage using 13 groundstations worldwide using store and forward and Near Real Time imaging and downlink

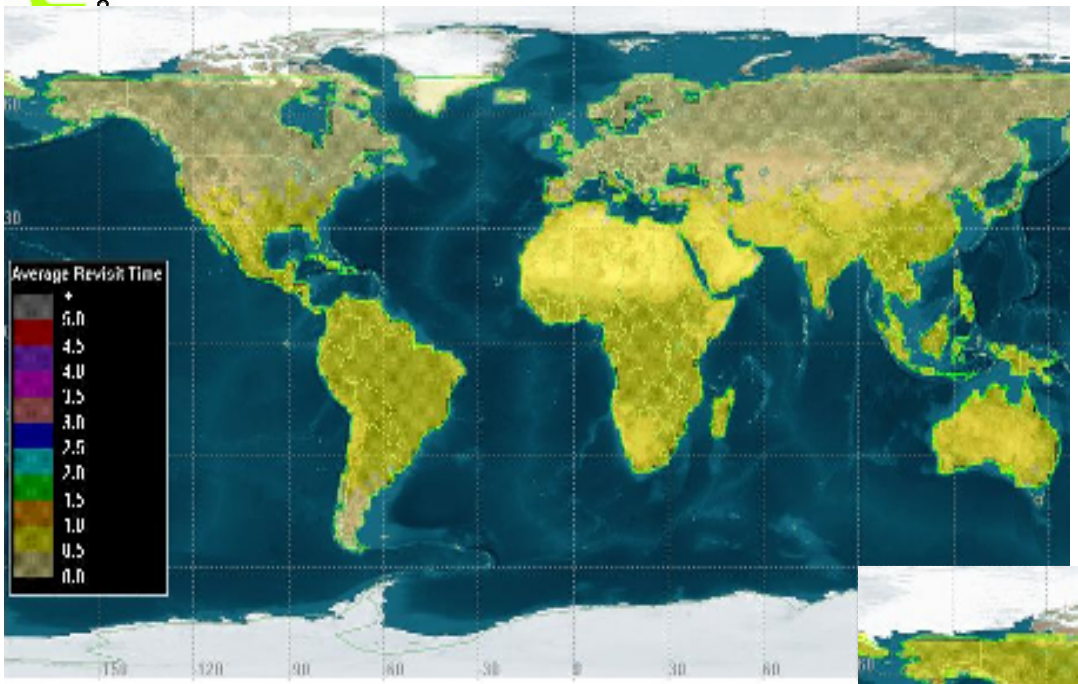


Direct Near Real time downlink service

- All data down-linked within groundstation access
- Windowed swath can provide full image length
- Narrow and long versus wide and short option
- Designed for Bit Error Rate of 10^{-9}
- Swaths (@ 80 Mbps)
  1. 300 km
  2. 220 km
  3. 660 km

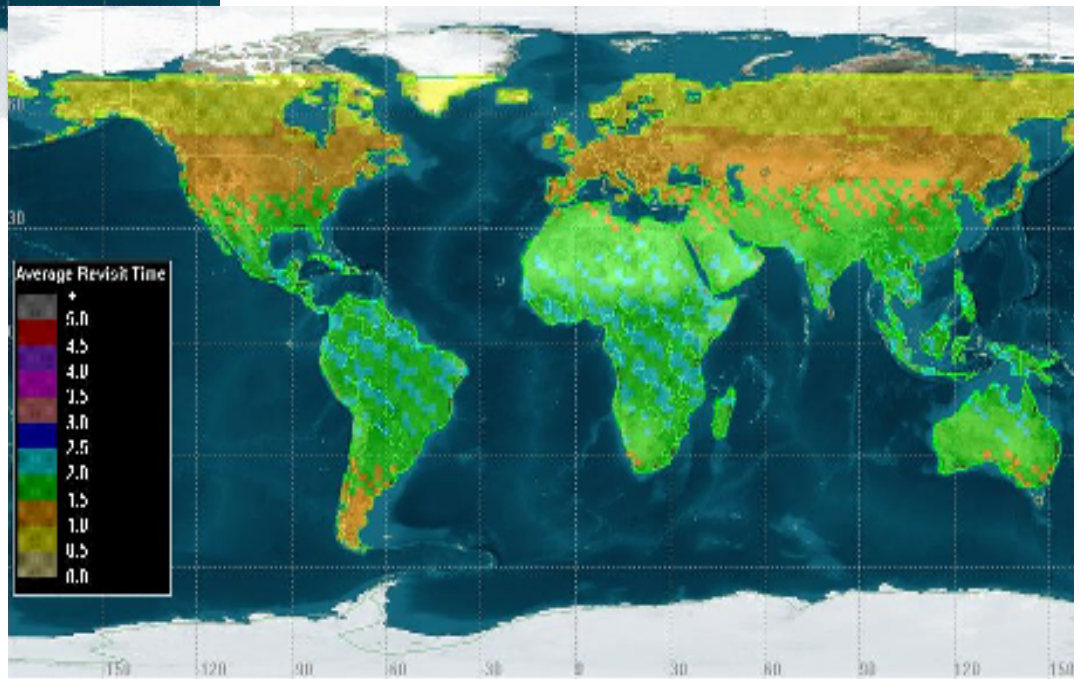


Future Constellation Performance Projection

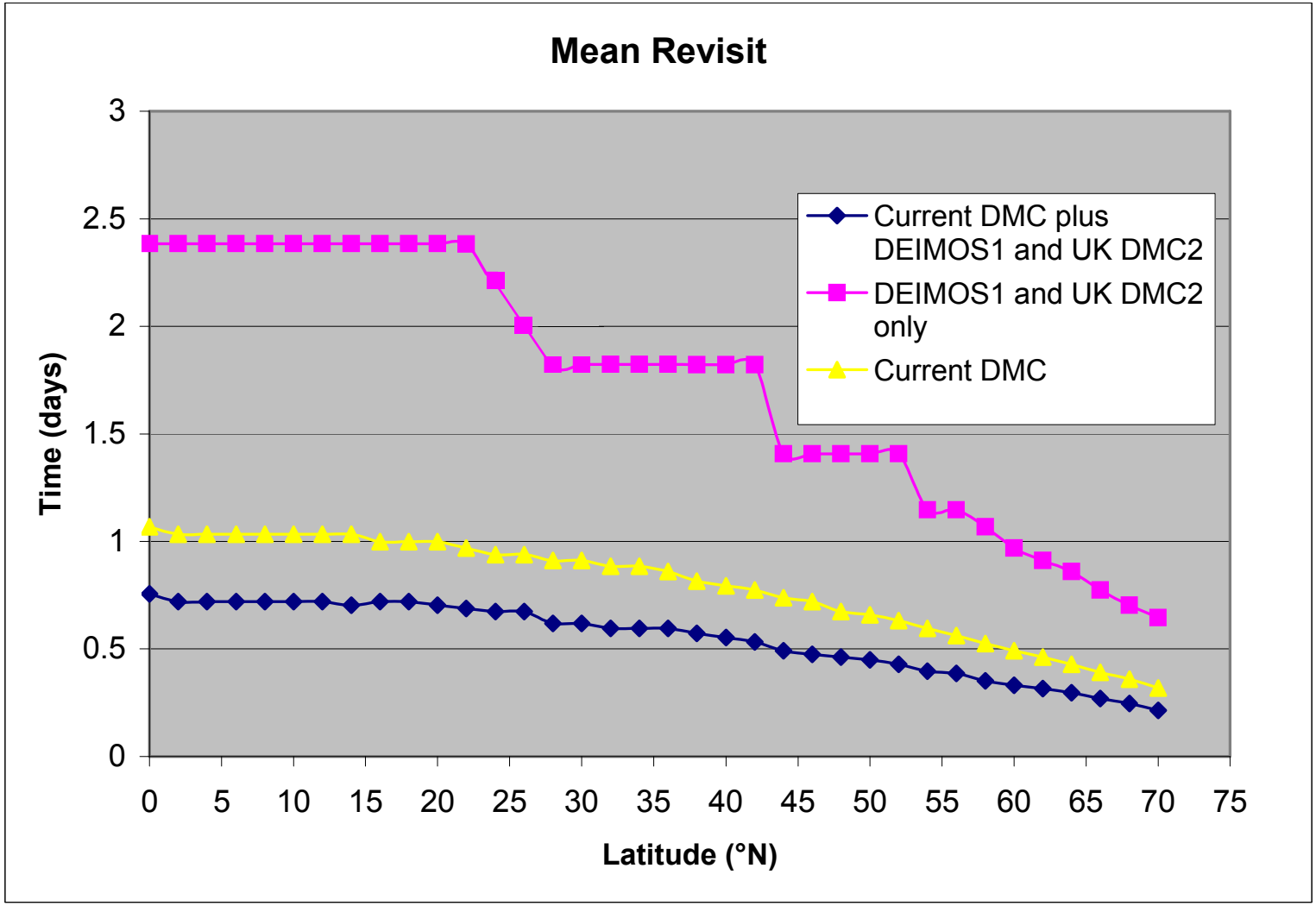


Future Constellation Mean Revisit (days)

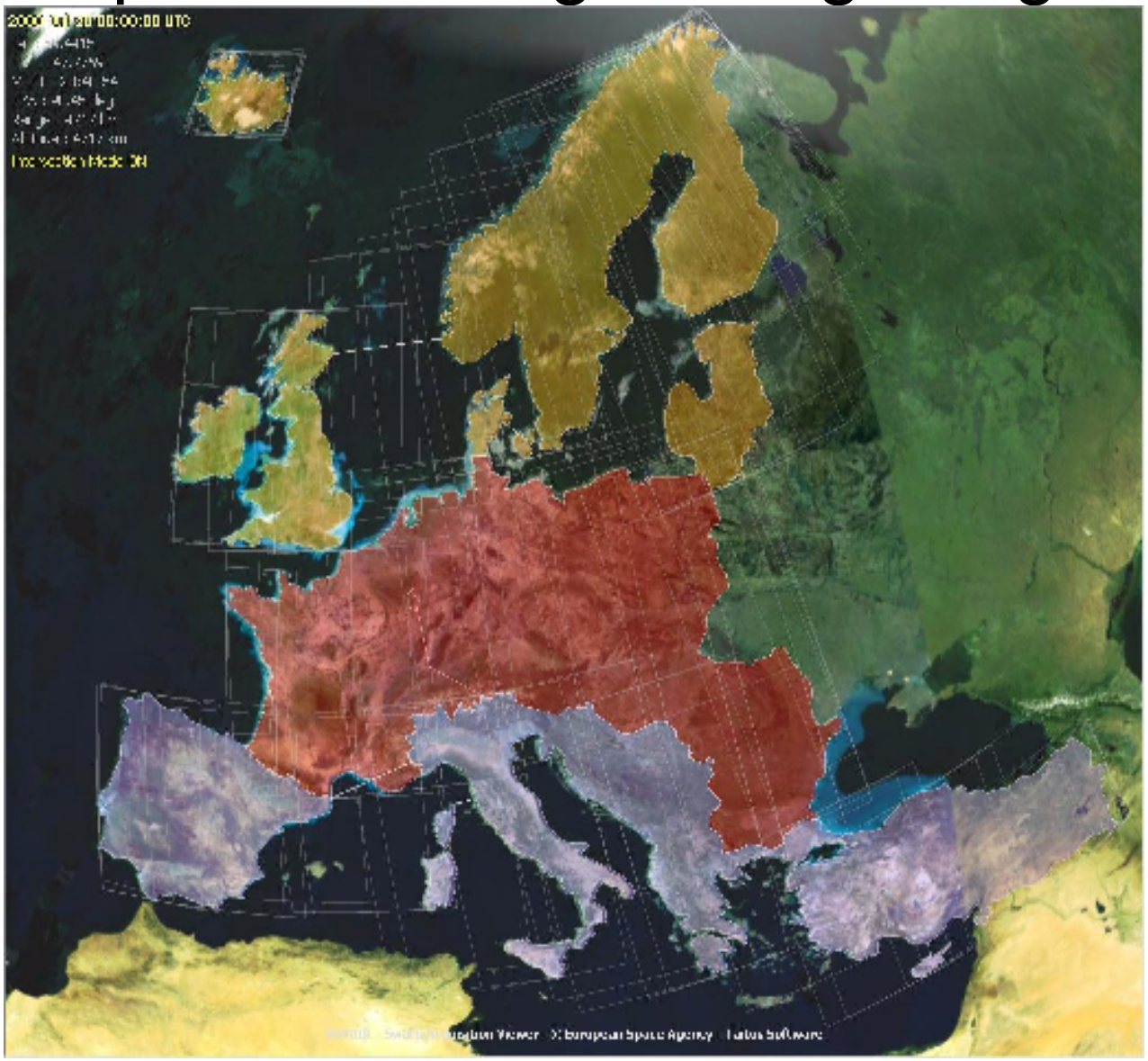
22m GSD Satellites Mean Revisit (days)



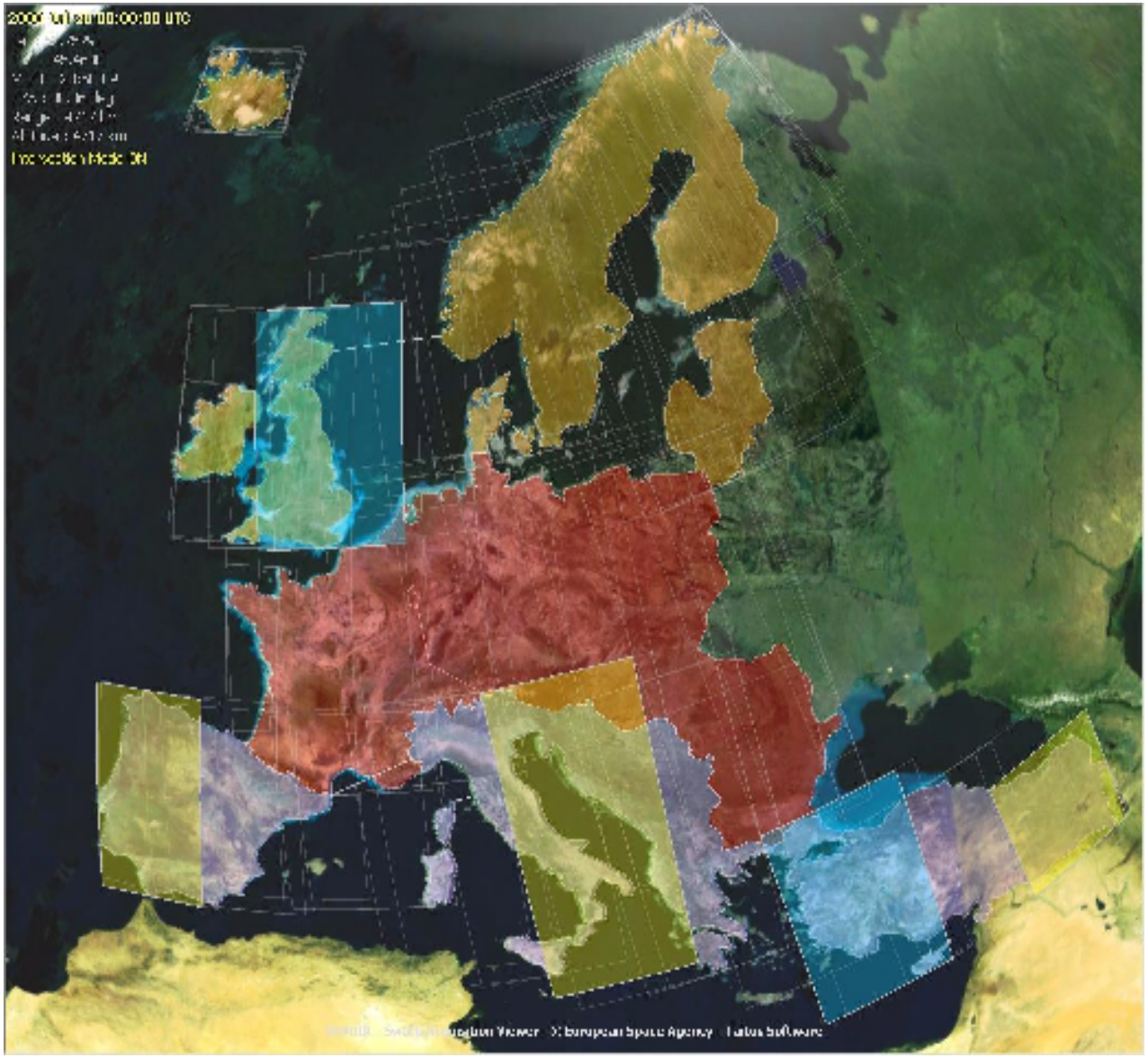
Revisit Time Analysis



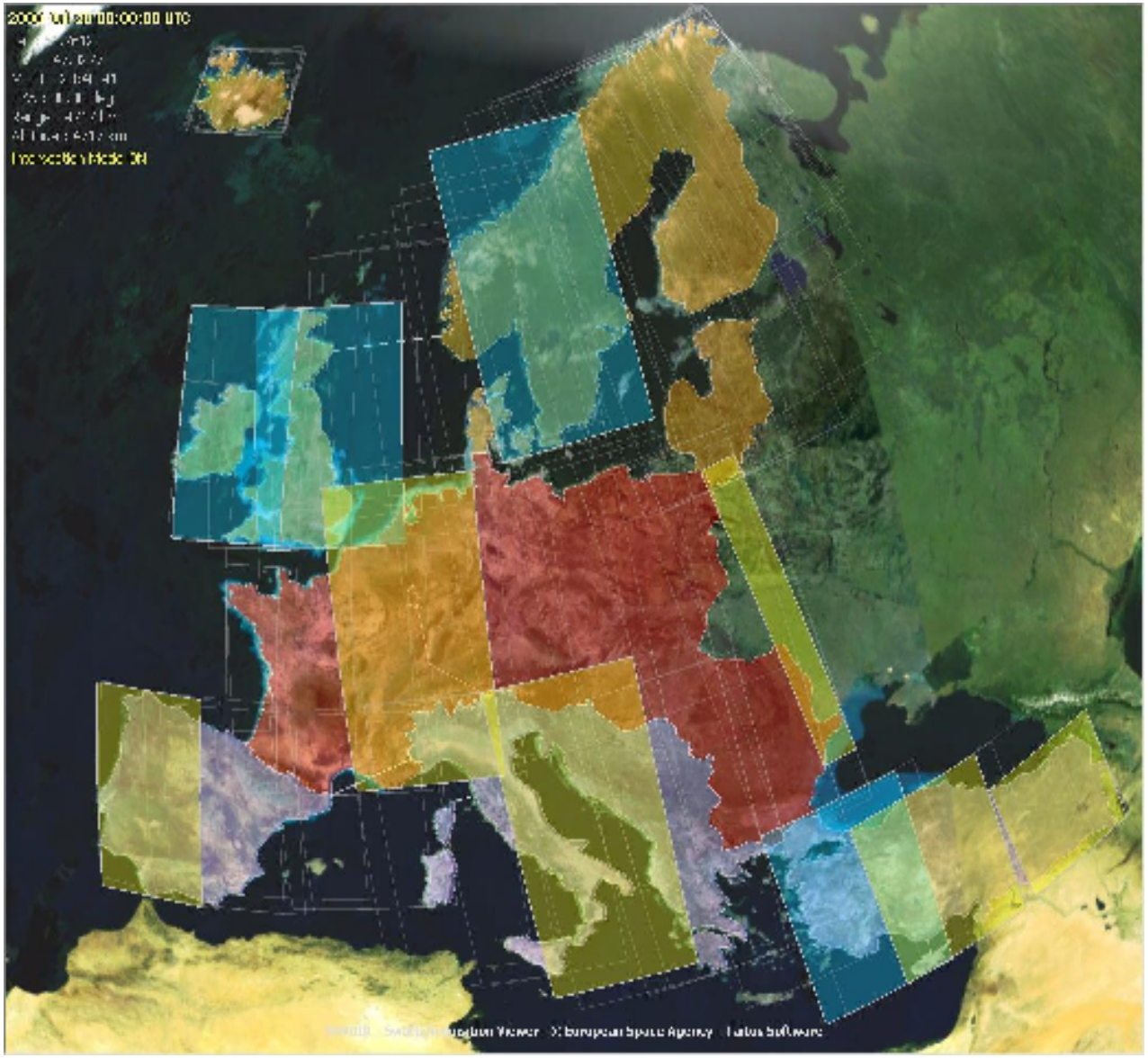
European Coverage - Target regions



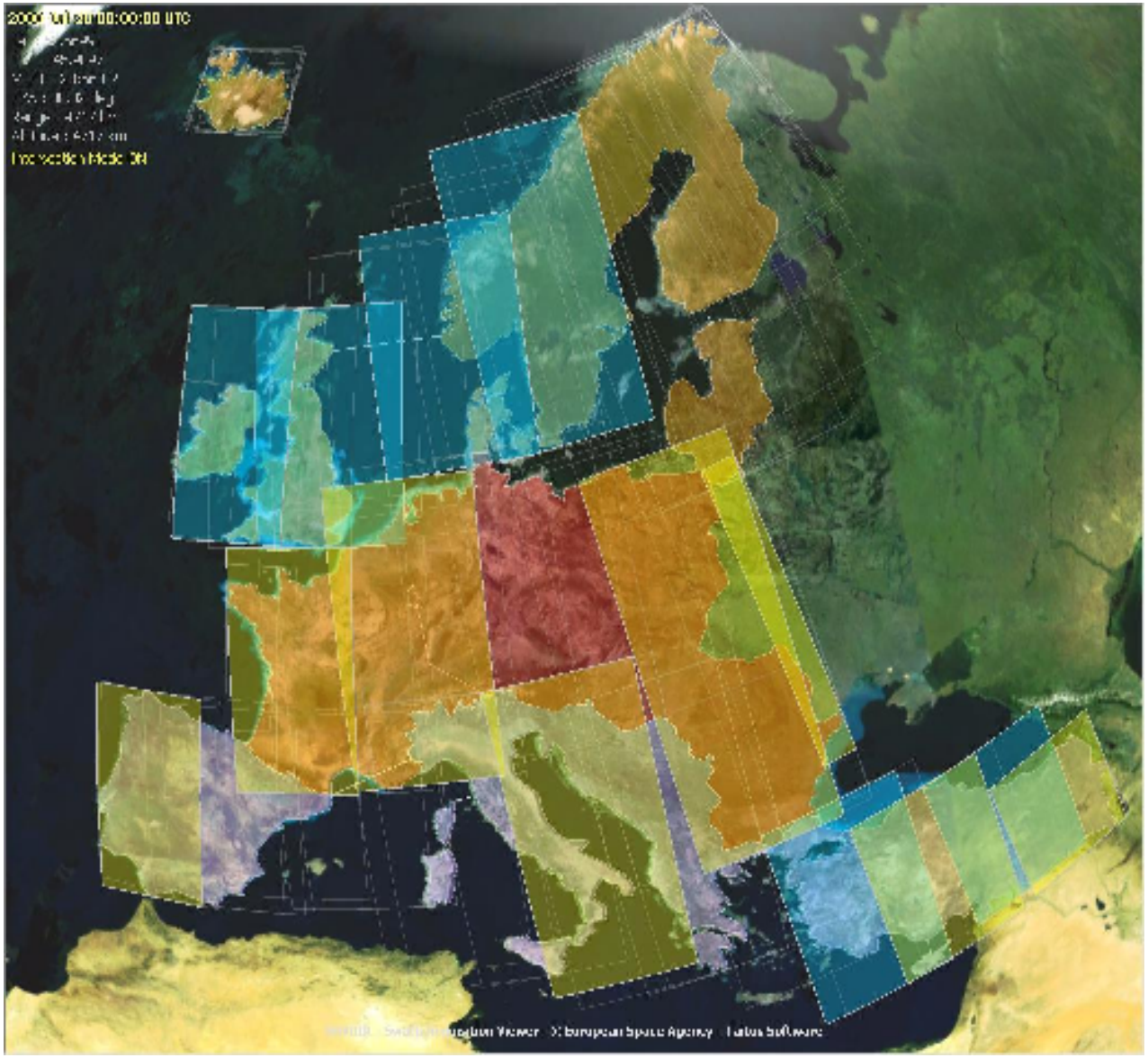
22m Data European Coverage – 1st Day of Imaging



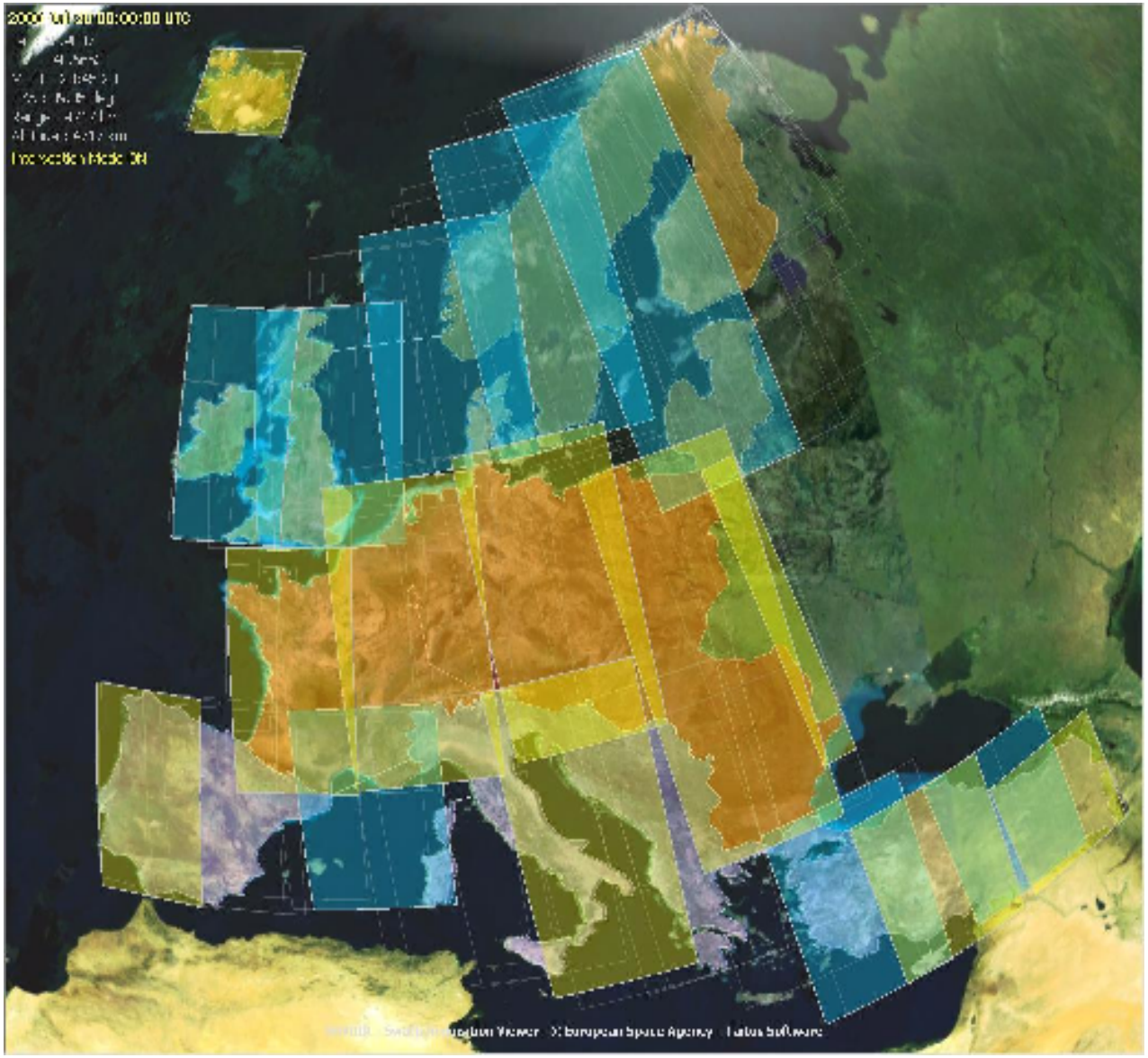
22m Data European Coverage – 2nd Day of Imaging



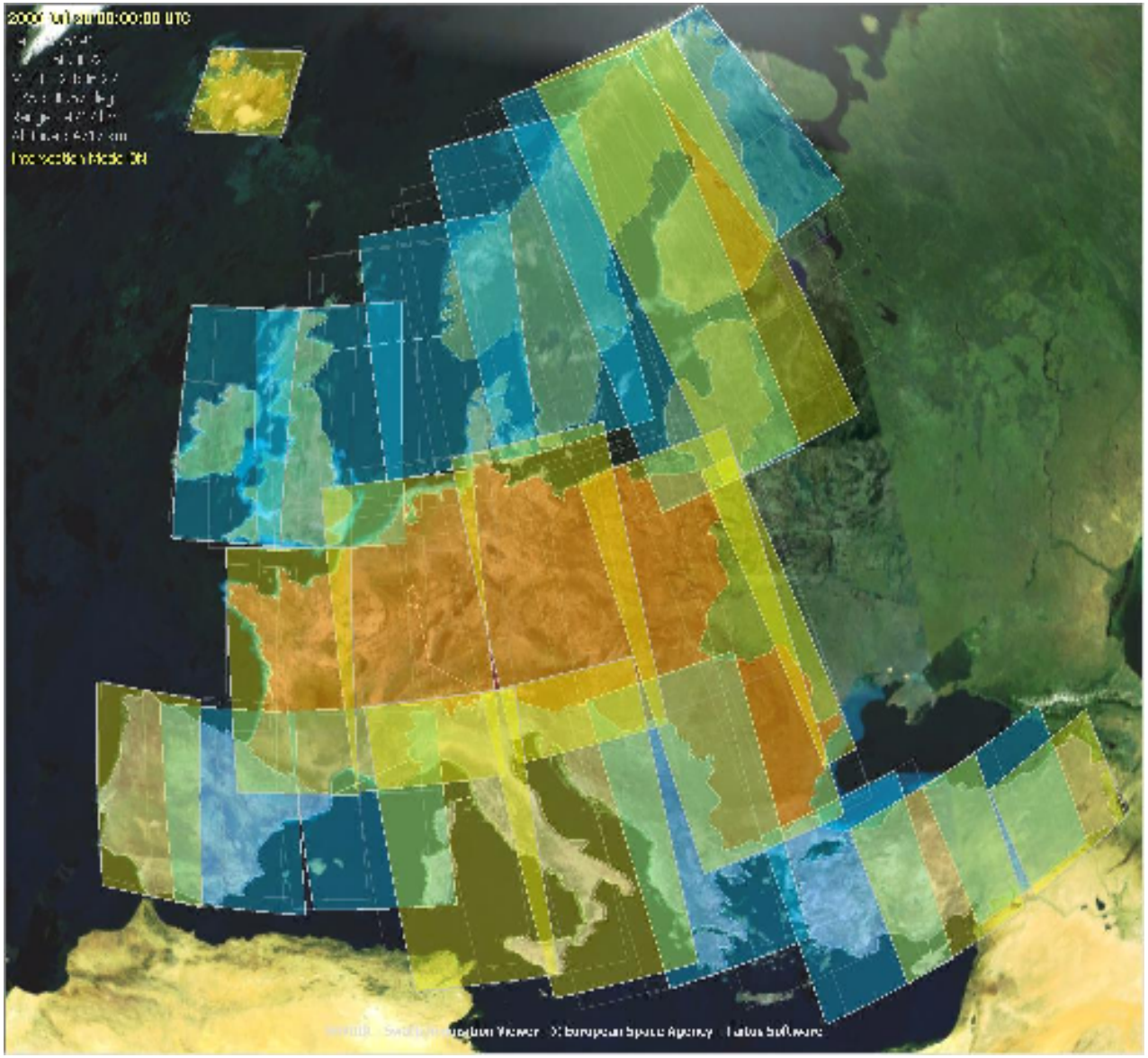
22m Data European Coverage – 3rd Day of Imaging



22m Data European Coverage – 4th Day of Imaging



22m Data European Coverage – 5th Day of Imaging



DMC-2; Key features

- Capacity for 2 season global monitoring
  - 2 DMC-2 satellites to launch 2nd Qtr 09;
  - 3rd DMC-2 satellite launch 2010
  - Up to 11.7 million sqkm/day/satellite (total 35 million sqkm /day)
  - Augments existing 4 satellite 32m constellation
- Daily revisit in constellation
- 4-5 day revisit for single DMC satellite

- 22 m gsd vs 32m gsd = double no. of pixels/sq km
- 10 bit data
- 650km swath
- 3 bands R, G, NIR
  same band pass as Landsat - same filter supplier
- Well calibrated data (radiometry <5%)
- Constellation cross calibrated <0.5%
- Orthorectified to sub-pixel vs Landsat ETM+ reference

DMCii Commercial Imaging Service

DMCii coordinates DMC Constellation to deliver

On-demand rapid imaging

- Fast responsive imaging service
  - 2.8 and 4 metre panchromatic
  - 5.6 metre multispectral
  - 32 metre multispectral

  New sensors
  - 22 metre multispectral (2009)
  - 2.5 metre pan/5 m multispectral (2010)

Country mapping

- Multi-season coverage

Precision Agriculture

- Flexible, short imaging windows to cover large or small AoIs

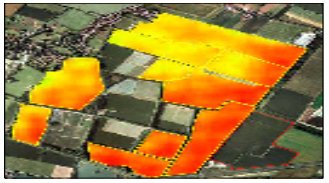
Forest mapping

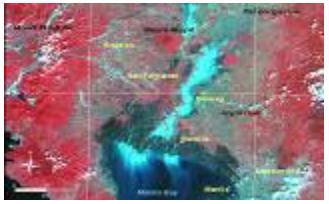
- Large area change detection and classification

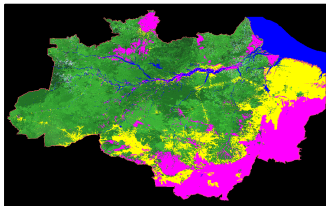
Direct downlink near real-time imaging

- 22 metre multispectral (2009)

On-line Archive access

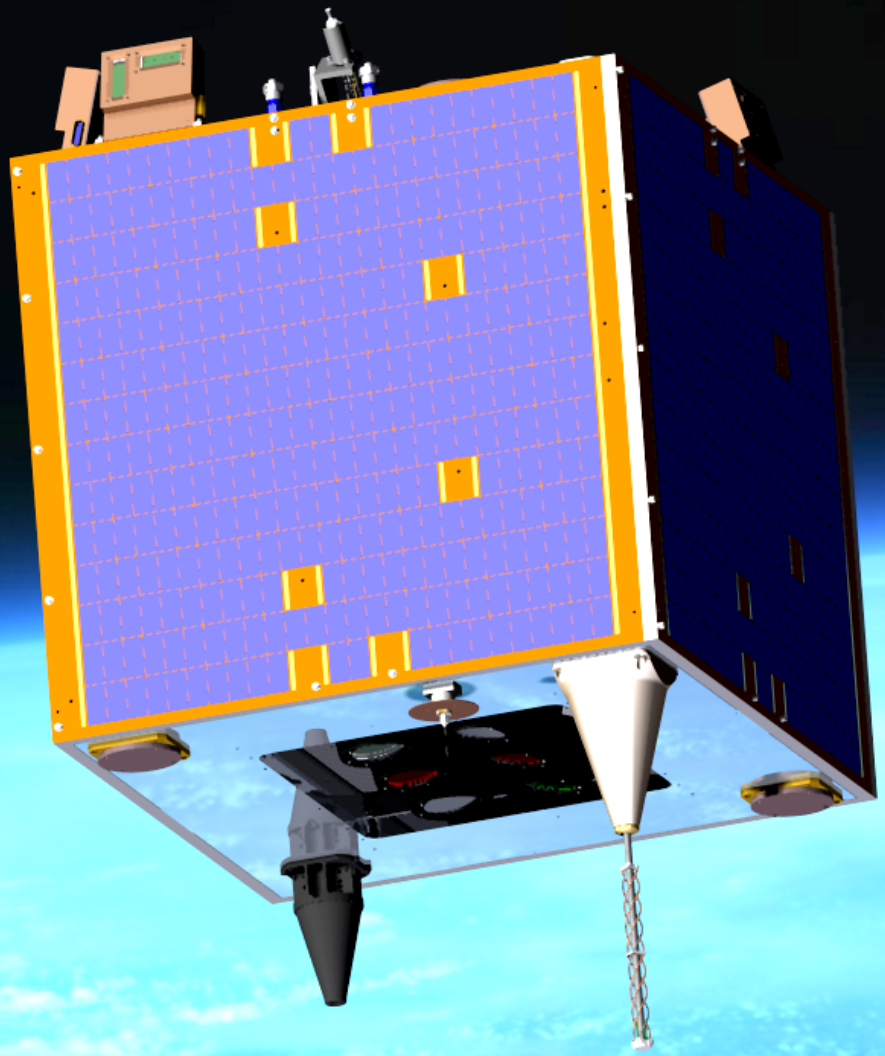




International Imaging

ASPRS Sustaining Member

www.dmcii.com



Questions ?